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NEPTUNE.

1896.	R. A. H. M.	Declination. °	Rises. H. M.	Transits. H. M.	Sets. H. M.
June 1.	5 6	+21 30	5 7 A.M.	12 24 P.M.	7 41 P.M.
11.	5 8	+21 32	4 30	11 47 A.M.	7 4
21.	5 9	+21 34	3 52	11 9	6 26
July 1.	5 11	+21 36	3 14	10 31	5 48

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Off right-hand limb, as seen in an inverting telescope.)

	H. M.		H. M.
I, R, June 1.	7 35 P. M.	II, R, June 9.	9 0 P. M.
IV, D, 2.	6 6 P. M.	I, R, 17.	5 53 P. M.
II, R, 2.	6 26 P. M.	IV, R, 19.	4 55 P. M.
IV, R, 2.	10 52 P. M.	III, R, 20.	7 42 P. M.
I, R, 8.	9 29 P. M.	I, R, 24.	7 48 P. M.

SOME LARGE PERTURBATIONS IN THE MOTIONS OF CELESTIAL BODIES.*

The novice in astronomy often believes that the motions of planets and satellites take place with great regularity, according to KEPLER'S laws, and that the disturbances caused by their reactions upon each other are only slight. A closer investigation shows, however, that the "harmony of the universe" is often seriously disturbed. In seeking for the reasons of these phenomena, the mathematical theory of planetary motions has been materially furthered, and convincing proof has been furnished that its foundation,—*i. e.*, NEWTON'S law of attraction,—is correct. Although one of these disturbances was already known in the early stages of the planetary theory, yet such great mathematicians as LAGRANGE and EULER could not give a sufficient explanation of it. We refer to the motions of *Jupiter* and *Saturn*, in which great deviations were discovered, increasing with the time.

It remained for LAPLACE, the real founder of celestial mechanics, to discover the reason, namely; that the times of revolution of the two planets stand very nearly in the relation of two to five. Deviations are thereby produced which, returning only after 900 years in the same order, become so summed up that the simple motions in the ideal elliptic orbits are completely destroyed. Similar phenomena occur wherever two celestial bodies, moving round the same main body, have times of revolution standing in a simple relation to each other. The greater the inclination of such orbits, and the more pronounced their elliptic eccentricity, the more marked, necessarily, are the deviations. It may even occur that the body cannot be observed for a long time, because we look for it at a place considerably removed from its actual position. As an example, the planet *Andromache* may be mentioned. Its time of revolution stands to that of *Jupiter* nearly in the relation of four to nine. It is evident that the movements of this small planet, having an orbit of great eccentricity, must be seriously disturbed by the giant *Jupiter*. These disturbances act for about 200 years in the same direction, and only after the expiration of this period in an opposite one. In consequence, the planet was actually lost to observation, and restored only by celestial photography. BERBERICH proved that in the mean time strange changes, reaching enormous figures, had taken place in its orbital elements.*

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* From the January number, 1896, of *Himmel und Erde*. Translated for the Society by Mr. C. A. STETEFELDT.

Satellites present an example of disturbances of a different kind. Of the eight satellites of *Saturn*, the sixth (*Titan*), and the seventh (*Hyperion*), are so connected that three revolutions of the latter require the same time as four of the former. Considering that the orbit of *Hyperion* deviates considerably from a circle (the focal points of the ellipse are distant from the center one-eighth of the major semi-axis), it follows that the two satellites must disturb each other considerably. *Titan*, discovered by HUYGHENS, the brightest of *Saturn's* moons, has been observed longest, and its orbit is well known through BESSEL'S measurements and calculations. *Hyperion* is the faintest of these moonlets, and was discovered in 1848 by BOND and LASSELL. Since then it has been accurately observed by HALL, in Washington, and by H. STRUVE, in Pulkowa, through their giant telescopes. According to HALL and STRUVE, the rapid retrograde movement of the major axis of the elliptic orbit is nearly 20° in one year.†

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* Nat. Rdsch. 189.

† With our Moon, the corresponding turning of the elliptic orbit is twice as much; but in this instance, it is the result of solar attraction, which is considerably greater than that of the Earth. In the case of *Hyperion*, it is produced by the attraction of another moonlet.

The theory of this body is, however, as yet so incomplete that the Paris Academy has announced a prize for a satisfactory theory. Such a theory also presupposes the determination of *Titan's* mass. On the other hand, a comparison of the theory with observations would give a determination of the mass. Thus, the mass of *Saturn* could be deduced with tolerable accuracy from the disturbances in *Jupiter's* orbit. In *Titan's* orbit similar deviations may be found, which, however, on account of the slight mass of *Hyperion*, must be less prominent than the disturbances of the latter. From these, nevertheless, the mass of even such a small body could be determined with some accuracy.

THE CIRCULATION OF THE ATMOSPHERE OF PLANETS.

By Marsden Manson, Ph. D.

Our knowledge of the circulation of the atmosphere of planets has been so befogged by detail, that the grand and simple principles involved are lost in the maze of irrelevant and incompetent data which has been woven about the subject.*

The problem is intricate when attacked solely from the standpoint of the meteorologist, and it is doubtful whether an explanation of the prime mode of action of solar energy in producing atmospheric circulation has place in any treatise or text upon the subject. It is certain that none of the laws and formulæ laid down in meteorology will explain the grandeur and the delicate balance of the movements observed in the atmosphere of *Jupiter*. Nor will these complicated and empirical rules explain the

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* The writer was led into making this investigation in a very peculiar manner, and it may not be inappropriate to outline the facts.

The amounts and distribution of rainfall upon the Pacific Coast became a subject of interest to the writer in 1877. This limited study broadened into a general one of the state of meteorology. Repeated failures to grasp the scope of the fundamental facts and laws, through these sources of knowledge, led into the general question as to whether the interpretations of meteorology would, in their simplest form, explain the movements observed upon *Jupiter*.

The view was entertained that the fundamental laws of the circulation of the atmosphere were true for all planets.

An apology is also due for the crudeness of the form in which these studies are presented — for their preparation has been confined to the moments which can be snatched from bread-winning in other lines.